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AUTHOR Hagopian, Tim
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ABSTRACT

In response to a decision at Worcester State College (Massachusetts) that remedial mathematics and other mathematics courses should be taught in a non-lecture format--learning by doing rather than by watching--a math computer lab was created. Three courses each have a 1-hour lecture per week, with students responsible for all additional learning and practice in the computer lab using publisher supplied tutorial and testing software. Students can make unlimited use of student lab aids/tutors free of charge. The lab also provides resources and tutoring for the rest of the college. Advantages to the lab based approach include: students learn independently; course consistency; self-pacing; cheating is minimized; and less "boring" lectures. Disadvantages include: more students "apparently go by the way-side"; multiple choice testing only; some students resist; one to two fewer full-time faculty are employed; and test score results are instant (not good for students who score very low). Any system works poorly if many students do not care to learn or work hard, have weak backgrounds, and work very long hours at jobs while attending school. With further refinements, and as new students each year have less anxiety about computers, the lab approach will only get better. Includes course syllabi and a chart comparing the effectiveness of traditional versus lab based class formats. (SWC)

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1 Thirty Station Math Lab + 2 Faculty = Managing 500 Students Successfully in Low-Level Mathematics Courses

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Tim Hagopian
Mathematics & Computer Science Dept.
Worcester State College
486 Chandler St.
Worcester, MA 01602
508-793-8000 X8607
Thagopian@worc.ma.edu

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About Worcester State College:

Founded in 1874 and located in central Massachusetts, we are an affordable public institution. With roots as a teachers' college, we now have various majors sitting in a liberal arts curriculum. Within a few miles of and in a consortium with three prestigious colleges, a community college, and three other small colleges, we have the largest enrollment.

Full time UG students: 2849
Part time UG students: 2073
Fall 95 freshmen applicants: 2283
Accepted: 1403
Enrolled: 486
Average combined SAT score: 878 (not recentered)
Total new students last year: 1160
BA/BS awarded last year: 650
Graduate students: 583
M.Ed./MS awarded last year: 130
Matriculating UG students: 3932
Commuters: 4850 Residents:655

Majors:

Health fields: 20%	Business/Econ.: 18%	Social Sciences: 17%	
Sciences/Math: 13%	Education: 11%	Humanities: 7%	Undeclared: 14%

Over half of our students work more than 20 hours per week.

Mathematics Situation:

In the late 1980's and early 1990's we were not offering our credited Basic Mathematics course but many students still needed an arithmetic & beginning algebra review.

In September 1992, the president, in agreement with the chair of the Math/CS department, Robert Perry, decided that remedial mathematics and possibly other mathematics courses should be run in a non-lecture format, reasoning that such basic high school concepts should be (re)learned by doing not watching yet another teacher explain them in a cloud of chalk dust. In

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Ideas & suggestions for change :

- Limit or eliminate tutorial use on a test due date. The lab is packed on due dates from students attempting to learn all of the material just before testing and from last day testers.
- Increase lab aid and MA 99 student contact. These students need more attention.
- Increase frequency of testing. The lab is not nearly as full during weeks of no test.
- Have publisher put student names on screen at all times to facilitate tutoring, conversing, etc.
- Increase incentives for student to study.
- Increase communication about grading and that learning is the issue of concern.

Conclusion:

I think any system works well if most students want to learn and work hard or are asked to do what comes easy to them. Conversely, any system works poorly if most students don't care to learn, have weak backgrounds, don't work hard, and work an impossible number of hours at their job. The latter is our case and neither the traditional system nor the new method works *well* in my eyes. However, with further small refinements and as the students each year come to us with less anxiety about computers, our lab approach will only get better. Presently, given this type of student population in these "bad math" times, it is clear we are having relative success.

Cover Sheet

Below is a cover sheet (format altered to fit below) which students must get from a staff member before taking a test. Note: We do not *always* "turn on" the computer timer.

USE THIS WORKSPACE AND CONTINUE ON REVERSE SIDE.

[This work*space* was deleted in order to fit in this document]

After completing the test, fold here (with name showing) and hand in (with any other work). No grade may be given without this completed document and your work.

Date: _____ **Name (print):** _____

Course: (circle) **MA 99** **MA110** **MA165** **Test Name:**_____

Section: (circle) **01** **02** **E___** **Start Time:**_____ **End Time:**_____

(The computer or a lab aid will end the test at the End Time)

You are required to show all work **neatly** and turn it in after completing the test. This document must be used as a cover page for your work. Begin your work above and continue on the back. When necessary, use another blank page to finish your work. By your signature you attest that the work which appears in your name here and on the computerized test is yours and that you neither received nor gave assistance during, prior to or after the test. There is a time limit for the test; the computer may end the test after that limit. Pressing the F10 key will end your test and cause it to be scored immediately. You cannot see your *exact* test ever again. To go over your test, you must see a staff member. We have a printed copy of the test but the questions are in a different order. If your work is neat and you circle the appropriate numerals below, *we* can find a particular question as well as your errors. (These numerals do *not* match up with *your* test.)

Signature:_____ **Grade:**_____

I II III IV V VI VII VIII IXX X

XI XII XIII XIV XV XVI XVII XVIII XIX XX

order to efficiently handle the droves of students that would need the new Developmental Mathematics (MA 99) course, the decision was made to create a Math Lab.

Entering students with a math SAT score below 500 are required to either pass an assessment test or complete MA 99. All other students can take any math courses they wish but must take at least one, normally two. College Algebra (MA 110) or Business Math (MA165) are typically one of the two math courses taken, noting that MA 99 credits do not fulfill the mathematics requirement nor can they be used towards graduation.

They hired me and expected technology to be used some way. It took us a few years of semi-high tech methods and $70,000 worth of equipment to pull it all together into one smooth operation. We haven't looked back since.

***The Fab* Math Lab**

In January 1994, Worcester State College tried a new approach in the delivery of MA 99 and MA 110. In January 1995, MA165 was added. Our Math Lab of 30 Dell, 486SX-25MH personal computers networked to a Dell, 486DX-66MH file server running Novell 3.11 handles the majority of the work. After the first year we saw the need for some minimal amount of lecture, which has been in place since. A full time faculty member runs MA165 & MA110, holding a one hour lecture per week for each section (we offer two sections for each course with 65 - 100 students in each section) and the students do the rest. I am the Math Lab supervisor and also run the MA 99 class in the same format. With publisher supplied tutorial and testing software, the students can come to the lab any time to learn or to take a test. Students can make unlimited use of student lab aids/tutors free of charge. Presently there are seven lab aids/tutors, working an average of 11.5 hours per week each.

The windows based tutorials which are specific to the student's text come with a record keeping feature, giving us the ability to monitor each student's quality of work and quantity of time as well as allowing the students to leave a "bookmark". The tutorials are also available on similar work stations in the computer center for late night and weekend use when the Math Lab is closed. However, until the whole campus is networked (in September 1996, six departmental LANs and more will be networked), we must separately down load records from the computer center's file server. These algorithm driven tutorials are quite sufficient, though at times tedious especially when entering long answers. We recently offered the MA110 students 10 free points toward their chapter 4 exam grade if they did all the tutorials with success (this would take 6 - 12 hours). With only 50% of active students doing it, the raw mean for the whole class was 8 points higher than previous semesters. This and other experiences tell us that the tutorials can do the job if students spend the time although the text is still recommended especially if students do not purchase the software for home use.

The on-line testing program supplied by the publisher allows instructors to create questions or choose from a large bank of publisher's questions to build a test. At a work station, students sign themselves on to take the multiple choice tests (up to six choices per question) with the questions and answer choices appearing in different order for each student. We have set up the Novell and testing software so that students can only sign on to the proper test and are only allowed one entry into a test. Only with staff assistance can a student take any test. The test is scored instantly for the student and the result is stored on the file server. If the student wishes to know which specific questions were answered incorrectly, s/he must record particular information (from the post-test diagnostic screen) on a cover sheet (see page 76) and see then see a staff member any time after the final due date for that exam. We have chosen to keep all

questions the same for each student in order to make exact test reviewing possible. However, the algorithm driven question generator makes it possible to give each student different questions.

Many publishing companies now have the above types of on-line tutorial, testing, and management utility software packages. As we were apparently the first to use such software to such an extent (in earlier years there was only one package available), we noted many bugs and had many suggestions for needed changes. The publisher listened closely and sent continual software updates. The newest features give me the ability to: do mass student name-i.d.-password sign on, disallow students to add themselves into a course, edit student sign-on information, create practice tests on the tutorial, and attain student summary information.

Some advantages we have noted of the lab based method are:

1. Students learn *how to learn* independently by reading, studying, and *doing* problems.
2. Consistency in course coverage, grading, text, etc.
3. Flexible scheduling and self-pacing for students. Students may take a test anytime before the due date or finish the course early.
4. One to two full-time faculty positions saved. $$$$$$
5. Cheating is minimized.
6. Less "boring" or "over my head" lectures.
7. Instant test score results - nice for the students who do well.

Some disadvantages to this lab based method are:

1. More students *apparently* go by the way-side.
2. One to two less professors employed.
3. Multiple choice testing only (this is only a problem for College Algebra where partial credit would have helped differentiate cases of no knowledge & some knowledge)
4. Some students resist and don't work hard. They rationalize that they need to be "shown how to do it".
5. Instant test score results - not good for students who score very low. They often leave the lab without any consultation, get upset & anxious, and start to give up.

More!

In addition to handling the approximately 500 students/semester in the three courses, the lab also provides resources & tutoring for the college. Students not in a math course or in other math courses may use the various tutorial software packages as well as receive tutoring. Other software packages presently available include Minitab, Mathematica, Mathematics Plotting Package, Converge, and ISETL. More and more each semester, the math faculty are integrating these packages into their statistics, pre-calculus, calculus, and higher level math classes. This increased use of computer assisted instruction coupled with the heavy use of the lab by MA 99/110/165 brought about the creation of Math Lab II, located across the hall from the Math Lab, in January 1996. Containing 29 pentium work stations networked to the Math Lab server, Math Lab II doubles as a computer assisted math class room and a lab facility for students enrolled in these other courses to complete computer based assignments.

All of the math lab's software can be used in conjunction with Intel's LANSchool which allows the professor to take control of other workstations effectively forming a computer chalkboard. This inexpensive package eliminates the need for a projector when running small classes in the lab. However, for our large classes, during the first two lectures of the semester,

we benefit greatly by using a projector in conjunction with a laptop which we connect to the file server by way of a 10base-t cable installed in the lecture hall which is luckily only 60 feet away.

The Math Lab is located very close to the math faculty offices and is open M-R 8:30am - 7:30pm and F 8:30am - 5:00pm with two evenings a week reserved until 9pm for evening courses. In addition to the 24' x 27'work station area of the lab, there is a 12' x 27' room attached for tutoring, advising, and lab operations as well as another smaller room which serves as a comfortable area where students, lab aides, and faculty can interact socially.

Outside Evaluation:

Our Math discipline underwent its semi-decade, outside evaluation this past year. C Edward Sandifer from the Department of Math & Computer Science at Western Connecticut State University in Danbury, Connecticut did the evaluation. The opening six paragraphs read:

"The following is a summary of observations made during a site visit to Worcester State College on December 6, 1995, together with a series of recommendations and suggestions based on those observations. The purpose of this visit was to conduct an evaluation of the mathematics programs at the college, as part of the College's continuing process of self-evaluation and external review of its programs. The evaluation included a review of a self-study prepared by the Department, a tour of relevant campus facilities, interviews with mathematics, computer science and other faculty, a review of official College publications, meetings with students and discussions with members of the administration.

Issues are addressed roughly in order of their urgency and importance.

Assessment of the Math Lab

The way the math lab is being used to deliver remedial and introductory courses may be unique. It is certainly quite advanced and innovative and probably nothing like it is being done anywhere in New England. It seems to be working, but thus far, no effort has been made to assess its effectiveness.

I recommend an immediate effort to gage the effectiveness of the Math Lab. The simplest way to do this would be to give each student the same placement examination at the end of the course that the student takes to be placed into the course in the first place and check whether the student improves on that test.

Without doing a statistically controlled experiment, one would probably be unable to determine exactly how much more or less effective the Math Lab is than the traditional delivery technique, but the simple pre-test/post test experiment should determine whether or not the Math Lab is working well enough. Probably, if half the students who start the remedial Math 99 course finish the course, and half of the ones who finish, score well enough on the placement examination that they would not be placed into Math 99, then the Math Lab is at least as effective as traditional methods.

If the Math Lab is as effective as it seems, then the rest of the world should hear about it."

We did as he recommended. The results and other information follow. Doing a similar study for the other courses would be much harder. Although, since I have taught many courses at Worcester State College in the traditional way (including theses three courses) and before that tutored hundreds of students enrolled in these courses, I have a good sense of the effectiveness. I think lab approach works as well as the traditional for most students, better for many, and worse for a few.

MA 99:

See syllabus on page 71. I decided to try once more with no lecture - bad idea.

Fall 1995 semester results:

Of 94 students enrolled:

68% covered at least 2/3 of the material

57% covered all the material

50% received passing grades

33% passed the 30 min. assessment test which had originally placed them in MA 99:

Fall 1994 semester results:

Of 190 students enrolled:

53% passed

MA 110:

See syllabus on page 72. We feel somewhat justified in covering intermediate algebra concepts because:

1. The independent style of learning is a challenge in itself.
2. These concepts are the ones needed in preparation for either follow-up course (Pre- Calculus or Business Calculus).
3. I've tried using a college algebra text but could only cover the intermediate algebra concepts - it was too condensed and most of our students cannot handle the slight rigor of college algebra concepts.
4. We keep many of our test questions difficult - often with a "none of these" as a 5th or 6th answer choice and since "close does not count", students must be exact.

See grade distribution comparison on page 74.

Comments on student success/failure:

* Half of the data in the Math Lab distribution of grades was taken before the switch to one hour lecture/week and before any enforcement of the MA 99 prerequisite

* The College Algebra (and Business Calculus and Statistics I) classes taught by *me* in the past traditional style were typically 50% pass and 50% fail & withdraw. I believe some professors scaled too much.

MA165:

See syllabus on page 73.

See grade distribution comparison on page 74.

Comments on student success/failure:

We feel the drop in "A" grades represents a truer distribution. We are alarmed at the high percent of failing grades but like MA110, we feel these students were the "D-" of the past. The lab approach is most effective for this course probably because it is *mathematically* manageable by most students and unlike algebra, a little work goes a long way. We hear more good comments from these students

WORCESTER STATE COLLEGE

Course Syllabus **MA 99-01** **Developmental Mathematics** Spring 1996

TEXT: *BASIC MATHEMATICS/ Fundamentals, Algebra, & Geo.* 3rd ed. Richard Williams, HarperCollins 1992

This course will cover operations with: integers, fractions, decimals, percents, exponential expressions & polynomials as well as linear equations & inequalities in one variable. You will master chapters 1-9 in preparation for the many courses that use these basic skills. An underlying goal of this type of course is to develop analytic and accurate thinking skills and independent study skills (which include textbook reading).

This course will be completed through the Math Lab. Typically, you will learn the material by doing many problems (homework) in the text or, when the material is very new to you, by reading the text and then doing problems. The average student needs to spend nine to twelve hours per week doing homework. Computer tutorials should be used to supplement your learning however you may do the majority of your learning at the computer if you wish. The Math Lab is here for you; use it as often as you want. Open, less busy and restricted hours will be posted. The staff and I are available should you have any questions and you are always welcome to ask a staff member for tutoring. ***Accelerating through the course is encouraged for students who are familiar with the material.***

GRADING: Pass/Fail grades only. **To Pass you must:**

- *Pass all nine 9 chapter tests & the final with a grade of at least 70%*
- *Successfully* ***complete*** *the whole tutorial on a particular chapter before taking a retake (if one is needed)*
  See a lab aid or me when you are ready to take the retake (we will check your computer tutorial)
- *Do the above in proper sequence & timing by the dates below*

Exceptions to some of the rules above *may* be granted for an individual maintaining an average of at least 87% or in cases of documented disabling conditions.

Test Name	Deadline	Material from:
99CH1T.QM	**01/30/96**	Ch. 1
99CH2T.QM	**02/08/96**	Ch. 2
99CH3T.QM	**02/15/96**	Ch. 3
99CH4T.QM	**02/28/96**	Ch. 4
99CH5T.QM	**03/14/96**	Ch. 5
99CH6T.QM	**03/27/96**	Ch. 6
99CH7T.QM	**04/10/96**	Ch. 7
99CH8T.QM	**04/23/96**	Ch. 8
99CH9T.QM	**05/07/96**	Ch. 9
99FINAL.QM	**05/14/96**	Above

In recognition of the fact that many students carry with them mathematical fears and gaps in prerequisite knowledge (due to experiences including: gender biased instruction; attending underprivileged schools; learning disabilities &/or anxieties gone unnoticed in early schooling, etc), I will meet with each student, upon request, affirming their diversity. Prior to the meeting, students must write about their past experiences (good & bad) in learning math, expressing what they think they know and don't know of mathematics and themselves learning mathematics. This will afford students the opportunity to reflect and self observe their lives with respect to the learning of mathematics and thereby gain enough insight to overcome anxieties and fill in the gaps.

Question almost everything but do not question what your job is right now because you have already chosen & started that job.

You are a student. You study. That's your job. Do it well.

WORCESTER STATE COLLEGE

Worcester, Massachusetts 01602

MA110 College Algebra Spring Semester

Professor: Alfred C. Johnson 1996

SYLLABUS

TEXTBOOK: "Intermediate Algebra," Lial, Miller and Hornsby, Harper Collins, 1992, Sixth Edition.

COURSE DESCRIPTION: This course will cover intermediate level algebra as a preparation for further mathematics study in precalculus and calculus. The main concepts covered include algebraic expressions, equations (linear, quadratic, rational and radical), applications, inequalities, the rectangular coordinate system and systems of equations.

COURSE PROCEDURES: This course will be completed primarily through the Math Lab. Typically, you will learn the material by studying your textbook, working on many of the problems in the assigned chapter, attending the weekly lecture/discussion in the Eager Amphitheater, completing the computer tutorials for the assigned chapters and getting help (when needed) from the Math Lab Instructor or the math tutors working in the Math Lab (S-106). All tests will be done on the computers in the Math Lab.

COURSE OUTLINE AND TEST SCHEDULE:

Material Covered	Test Name	To Be Taken By MA110 01 & MA110 02
Ch.2-Sec. 2.1-2.3 & 2.5-2.7	110CH2.QM	02/07/96
Ch.3	110CH3.QM	02/21/96
Ch.4-Sec. 4.1-4.7	110CH4.QM	03/06/96
Ch.5	110CH5.QM	03/27/96
Ch.6	110CH6.QM	04/10/96
Ch.7-Sec. 7.1-7.4	110CH7.QM	04/24/96
Ch.8-Sec. 8.1-8.3	110CH8.QM	05/07/96
All of the Above	110FIN.QM	05/16/96

GRADING POLICY:

1. Seven chapter tests will be taken during the semester. The lowest test score will be discarded from the grade calculation. The arithmetic mean of the six remaining test scores will constitute 70% of your course grade.
2. The cumulative final examination will constitute 25% of your course grade.
3. Class participation/attendance will constitute 5% of your course grade.
4. No make-up tests will be given in this course.

WORCESTER STATE COLLEGE

Worcester, Massachusetts 01602

MA165 Business Mathematics Spring Semester

Professor: Alfred C. Johnson 1996

SYLLABUS

TEXTBOOK: "Mathematics for Business," Salzman, Miller, Hoelzle Harper Collins, 1994, Fifth Edition.

COURSE DESCRIPTION: The main concepts covered in this course include review of the basics of mathematics, banking services, taxes, insurance, business statistics, wages and payroll, markups and markdowns, commercial discounts and interest.

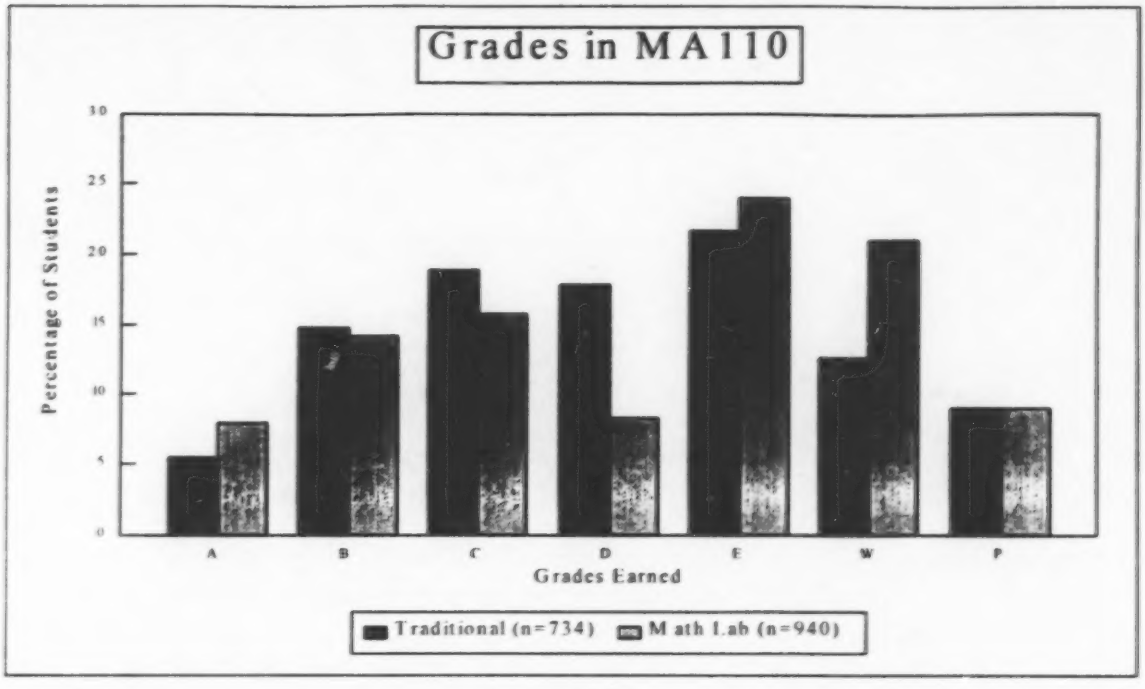
COURSE PROCEDURES: The course will be completed primarily through the Math Lab. Typically, you will learn the material by studying your textbook, working on many of the problems in the assigned chapter, attending the weekly lecture/discussion in the Eager Amphitheater, completing the computer tutorials for the assigned chapters and getting help (when needed) from the Math Lab Instructor or the math tutors working in the Math Lab (S-106). All tests will be done on the computers in the Math Lab.

COURSE OUTLINE AND TEST SCHEDULE:

Material Covered	Test Name	To Be Taken By	
		MA165 01	MA165 02
Chs. 2 and 3	165T1.QM	02/05/96	
Chs. 4 and 6	165T2.QM	02/16/96	
Ch. 5-Sections 5.1-5.5	165T3.QM	03/04/96	
Ch. 7	165T4.QM	03/25/96	
Ch. 8	165T5.QM	04/08/96	
Ch. 9 and 10.1	165T6.QM	04/22/96	
Ch. 11-Sections 11.1-11.4 and Ch. 19-Sections 19.1-19.3	165T7.QM	05/06/96	
All of the Above	165FN.QM	05/16/96	

GRADING POLICY:

1. Seven chapter tests will be taken during the semester. The lowest test score will be discarded from the grade calculation. The arithmetic mean of the six remaining test scores will constitute 70% of your course grade.
2. The cumulative final examination will constitute 25% of your course grade.
3. Class participation/attendance will constitute 5% of your course grade.
4. No make-up tests will be given in this course.



Data taken from past two to four years from all day, evening, and summer sections taught by full-time Worcester State College Employees.